Appl. No. 09/888,616

REMARKS / ARGUMENTS

In the description and drawings applicant has made minor amendments to correct typographical and other errors due to inadvertence, which, applicant submits, are self-explanatory upon reading the amendments, and do not affect the invention claimed nor add additional subject matter to this application.

Reconsideration is respectfully requested of the objection to the claims in view of the Calabro reference. In particular, original claims 1 to 21 were rejected by the Examiner as being anticipated by Calabro. Applicant respectfully traverses this rejection.

Claims 1 to 21 have been cancelled, without prejudice, and new claims 22 to 61 are submitted in their place. New claims 22 to 61 have been amended to clearly set forth the invention as a system and method for process control in combustion applications. In particular, it is respectfully submitted that the concept of providing a tunable diode laser for generating a frequency modulated near-infrared laser beam (see page 10, line 20 to page 11, line 21 of the application), transmitting the near-infrared laser beam through off-gas produced by the combustion application, detecting the transmitted laser beam, and analyzing the detected laser beam for select CO and H_2O absorption lines to determine CO concentration (see page 28, line 25 to page 29, line 17) is unique in this industry. Moreover, this unique and advantageous system and method allow for a control system to adjust select inputs to the combustion application in response to the CO concentration to improve energy efficiency (see page 2, lines 2 to 7, and page 7, line 24 to page 8, line 2).

Calabro does not teach nor suggest such a system or method as provided in the instant application and now claimed. In particular, Calabro is directed to reducing pollutant gas levels, whereas the instant application is directed towards energy efficiency and better quality metal production. Calabro does not use any modulation of the laser beam to enhance its sensitivity. Rather Calabro just scans the laser current to sweep the wavelength across the absorption signal of the gas species of interest and take line shape measurements.

At the elevated temperatures found in metallurgical furnaces (the type of combustion applications referred to in the instant application) the CO signal will have significant interference with neighboring H_2O absorption lines. As a result of this, it is not possible to get an isolated CO absorption line where line shape measurements can be made as disclosed in Calabro—the neighboring H_2O signals combined with the CO signal distort the line shape.

By using the frequency modulation technique disclosed in the instant application, and now claimed, applicant is able to narrow the absorption lines thus reducing interference by other species, such as water, which, as indicated in the application, is a particular problem at high temperatures. The problem of interference between CO and H_2O are detailed in the application, for example, at page 15, commencing line 7.

Applicant, therefore, uses frequency modulation to make the signals appear narrower, and therefore less prone to interference from neighboring signals.

Moreover, in applicant's application, and as now claimed, the CO concentration is determined through analysis of select CO and H_2O absorption lines. In particular, in the instant application CO concentration in determined through the use of a predetermined calibration curve which is a function of CO concentration and CO absorption and

temperature. In the embodiment disclosed in the instant application the temperature of the off-gas is determined from select H_2O absorption lines (see page 25, lines 1 to 15, and page 29, line 1 to line 17).

Calabro, on the other hand measures concentration from the intensity of transmitted light (see column 7, lines 5 to 18 of Calabro) and identifying the Gaussian component. As such Calabro failed to teach or suggest that the CO concentration is determined through analysis of select CO and H_2O absorption lines, and particularly by use of predetermined calibration curves as disclosed and claimed in the instant application.

As is evident, the claimed invention is not only different from Calabro, but provides significant and unanticipated advantages thereover. In particular, applicant submits that Calabro does not teach or suggest a system and method for process control in combustion applications by providing a tunable diode laser for generating a frequency modulated near-infrared laser beam, transmitting the near-infrared laser beam through off-gas produced by the combustion application, detecting the transmitted laser beam, and analyzing the detected laser beam for select CO and H_2O absorption lines to determine CO concentration to allow for a control system to adjust select inputs to the combustion application in response to the CO concentration to improve energy efficiency.

Accordingly, it is respectfully submitted that all of the objections and rejections have been addressed, and that the present application is in condition for allowance and an early notice to that effect is earnestly solicited.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned "**Version with markings to show changes made.**"

Should the Examiner have any further issues outstanding, applicant invites the Examiner to call the undersigned at (416) 957-1697.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Specification:

Paragraph beginning at line 8 of page 4 has been amended as follows:

The present invention provides a~~n apparatus~~ system for process control in a combustion application, comprising a tunable diode laser for generating a frequency modulated near-infrared laser beam, a transmitting means for transmitting ~~a~~ the near-infrared laser beam through off-gas produced by the combustion application, a detecting means for detecting the transmitted laser beam, a controller means for analyzing the detected laser beam for select CO and H_2O absorption lines to determine CO concentration, and for producing an electrical signal in response to CO concentration ~~and converting the detected laser beam to an electrical signal~~, and a control system for providing adjustment of select inputs to the combustion application in response to the electrical signal from the ~~detecting~~ controller means.

In the invention disclosed, the controller comprises means for providing predetermined calibration curves to determine CO concentration. In particular, the calibration curve is CO concentration as a function of CO absorption lines and temperature. For the embodiment disclosed, the controller determines the temperature of the off-gas from analysis of the H_2O absorption lines, and particularly H_2O absorption lines that respond differentially to changes in temperature. In the preferred embodiment disclosed the temperature of the off-gas is determined from the ratio of two H_2O absorption lines. The CO absorption lines are chosen where they have a profile of strong lines as compared to H_2O.

The paragraphs spanning line 28 of page 4 to line 10 of page 5 have been amended as follows:

This invention also provides for a method of process control in a combustion application, comprising:

a) transmitting a frequency modulated near-infrared laser beam through off-gas produced by the combustion application to target CO and H_2O;

b) detecting the transmitted laser beam; and

c) analyzing the detected laser beam for select CO and H_2O absorption lines;

d) determining CO concentration from the CO and H_2O absorption lines;

e~~e~~) adjusting select inputs of the combustion application in response to the ~~detected transmitted laser beam~~ CO concentration.

In the method disclosed the CO concentration is determined using predetermined calibration curves. In particular, the calibration curve is CO concentration as a function of CO absorption lines and temperature. For the embodiment disclosed, the method targets H_2O absorption lines to determine the temperature of the off-gas, and particularly H_2O absorption lines that respond differentially to changes in temperature. In the preferred embodiment disclosed the temperature of the off-gas is determined from the ratio of two H_2O absorption lines. Moreover, the method of a preferred embodiment of this invention targets CO as one off-gas for analysis, and particularly where CO has a profile of strong lines compared to H20. ~~Further, the method also targets H_20 to measure both temperature of the off gas and H_2O concentration.~~ While temperature measurements are necessary from a spectroscopic point of view, they are also valuable from other perspectives, including process control, quantification of exhaust gas thermal energy, improved air pollution control system design and operation, and others.

Paragraph beginning at line 17 of page 14 has been amended as follows:

Using a 90/10 beam splitter 56, approximately 10% of the laser beam 58 is passed to reference cell 54 to lock the laser onto the selected absorption feature. For room temperature measurements (approximately 0–50°C) reference cell 54 at atmospheric pressure (approximately, 100 kPa) can also serve as a secondary calibration standard. For high temperature applications, however, as, for example, found in the exhaust duct of an EAF, the calibrations found in reference cell 54 for the targeted species are inadequate. High temperature applications require calibration curves to be calculated and stored, for example, in computer 52~~, or, for example, in a calibration cell 55~~. The remaining 90% of the beam is used for the measurement channel.

Paragraph beginning at line 14 of page 20 has been amended as follows:

Since the magnitude of the modulated signal of the gas detected at 2f is proportional to the laser return power, it is important that the power be continuously monitored. The power varies from time to time due to the dust loading and the debris that crosses the laser beam. Also, the background radiation level from the arc in an electric arc furnace can be significant. A part of the background radiation from the arc that falls on the detector bandwidth is easily detected as well, along with the 'true' laser return power. This background ~~power~~ radiation is ~~be~~ monitored and subtracted to obtain the true power to compensate for the changing magnitude of the measured signal due to dust, debris and optical misalignment. In the current configuration, the laser current is switched "OFF" as at 71 for a very short period of time at the end of each integration

cycle. The background radiation that is seen by the detector is measured during this period. The laser is then switched "ON" and the scan continues.

Paragraph beginning at line 12 of page 30 has been amended as follows:

A schematic of an EAF system using the process sensor of this application is shown in Figure 15. A more detailed view of the exhaust duct is shown in Figure 16. In general Figure 15 shows an EAF 10 having an exhaust duct 20. A laser source 26 is provided to transmit a laser beam through fibre optic cable 28 to a launcher assembly 30 (see Figure 16). The laser beam is transmitted across duct 20 as at 60 to detector 32 which, in turn, transmits an appropriate electronic signal back to source 26 via a coaxial cable 34. It can be appreciated that a fiber optic cable can also be used in place of coaxial cable 34. Source 26, through use of a computer that can be located on-board (for example, see Figure 4) uses the calibration curves calculated for high temperature applications to interpret the readings of the concentration of, for example, CO, from detector 32 and sends an appropriate signal to an EAF process control system 62. Control system 62 can then adjust the oxygen flow through controller 64, or temperature of the EAF through, for example, natural gas flow controller 66, as needed. ~~As illustrated~~ Figure 15 illustrates a process control system that uses ~~a~~ real time sensors to obtain selective measurements of the off-gas constituents and provides adjustment of the inputs to a furnace (such as oxygen, fuel, electric power, etc.) on a continuous feedback loop.

<u>**In the claims:**</u>

Claims 1 to 21 have been canceled, without prejudice.